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MUSKMELON PRODUCTION IN CALIFORNIA

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Muskmelons are one of California's major vegetable crops, ranking fourth in acreage planted and fourth in economic importance—exceeded only by tomatoes, lettuce, and potatoes.

This circular supplies information on the varieties adapted to California, and discusses all cultural operations, diseases, insect pests, harvesting, and packing and shipping.

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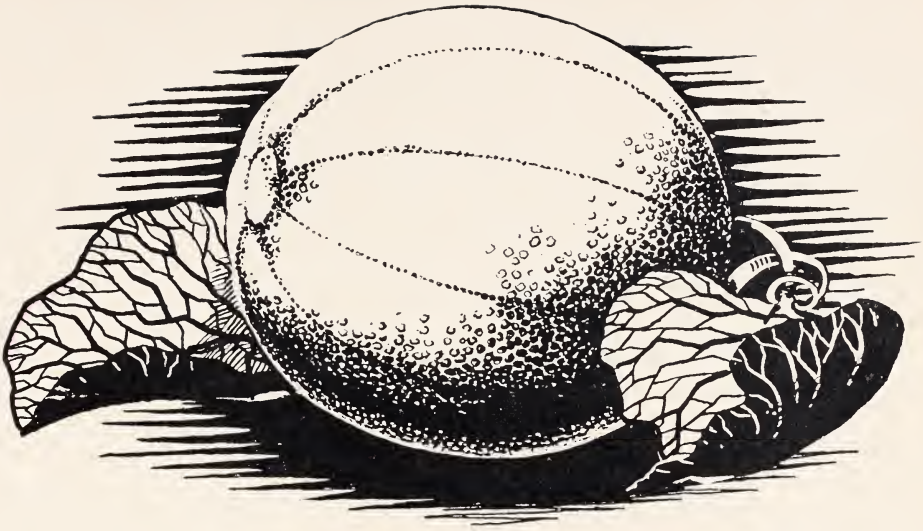


MUSKMELON PRODUCTION IN CALIFORNIA

Muskmelons, *Cucumis melo* L., belong to the gourd family, as do other vine crops such as cucumber, watermelon, pumpkin and squash. Muskmelons probably originated in Africa, as do 25 to 30 other species of *Cucumis*. Wild, primitive muskmelons have been found in Africa.

Compared with other cultivated crops, muskmelons are relatively new to the world's assemblage of crop plants. Under the guidance of man, muskmelons have become amazingly diversified in a comparatively short period. The Russians and our own plant explorers have shown that there are several strong secondary centers of diversity in India, Iran, Russia and China, suggesting that muskmelons quickly became an important crop in these areas.

The plants are annual, hirsute, trailing vines, with 3 to 5 runners that may attain a length of 10′ to 12′. The runners produce short fruiting branches which bear the perfect flowers and later the fruit. The plants have a short, thickened taproot that sends out lateral roots about 6″ to 8″ below the soil line. The laterals grow outward and downward and are covered with small fibrous roots.

The pollen of muskmelon flowers is heavy and slightly sticky. Therefore, insects are required for fertilization. Even perfect flowers are not fertilized by their own pollen without the intervention of insect activity. Experimental work has shown that commercial production of muskmelons without the aid of pollinators is impossible. The domestic honey bee is the only known effective pollinator of muskmelon flowers. Thrips, beetles and native bees are not factors in muskmelon pollination. Two honey bee colonies per acre are recommended for adequate pollination.

CLIMATE AND SOILS

Climate

Muskmelons, native to warm and humid, or sometimes arid regions of the world, require relatively long periods of preferably dry, warm weather. Plants are easily killed by frost during all stages of development. You can protect seedlings from injury by light frosts with paper covers; without such protection the entire growing season must be free from frost.

Plenty of sunshine, low humidity, and absence of rain tend to prevent the fungus diseases that often defoliate the plants in humid areas. Defoliated plants produce high proportions of cull fruits that cannot be marketed because they are too small, lack well-developed net, or have sunburned spots. The flesh of fruits from defoliated plants is insipid and low in sugar. A great deal of sunshine on the foliage produces vigorous plants that yield high-quality fruits with firm flesh, high sugar content, and fine flavor.

These climate requirements make California's warm, dry interior valleys an excellent environment for the culture of muskmelon.

Soils

Muskmelons can be grown on several types of soil but not on muck. Peat, heavy clay, or adobe soils are not recommended. For early maturity use the lighter soils such as sandy loams or silt loams; they have good drainage, open texture, and warm up early in the spring. Greatest total yields, however, are often obtained from crops grown on heavier soils, where the water-holding capacity of the soil is of prime importance. Use heavier soils for crops that mature in late summer and early fall.

Muskmelons require soils that are fairly fertile, well drained, relatively free from nematodes and parasitic fungi, and well supplied with organic matter. You will get good results from turning under cover crops or from adding animal manures before planting. Excellent crops, however, can be produced with commercial fertilizers alone.

Muskmelons are sensitive to acid soils. They thrive best on neutral or slightly alkaline soil. They are among the plants that benefit most from the application of lime to acid soils.

PRODUCTION AREAS

With few exceptions, muskmelons have been grown in California in the same areas for many years. The most notable changes have been the planting of a limited acreage for fall harvest in the Imperial Valley and a big shift in acreage from the early crop in the Imperial Valley to the summer crop in the San Joaquin Valley, and particularly to Fresno County.

Producing areas are more or less arbitrarily divided according to season: spring, midsummer, and late summer or fall, to correspond with the annual reports by the California Crop and Livestock Reporting Service, sponsored jointly by the USDA and the California State Department of Agriculture (see the listing on top of the next page.

Season	Planting dates	Usual harvest dates			Counties
		Begins	Most active	Ends	
Spring	Dec.–March	May 1	June 1–June 30	July 10	Imperial, Riverside
Midsummer	March–June	June 25	July 10–Sept. 10	Oct. 10	Butte, Fresno, Kern, Kings, Los Angeles, Madera, Merced, Riverside, San Bernardino, San Diego, San Joaquin, Stanislaus, Sutter, Tulare
Early Fall	July–August	Sept. 25	Oct. 1–Oct. 31	Nov. 30	Fresno, Imperial, Kern, San Joaquin, Stanislaus, Tulare, Yolo, Yuba

VARIETIES AND VARIETAL IMPROVEMENT

Muskmelons include several botanical varieties, each containing one or more horticultural varieties. The varieties of economic importance for California are listed here:

Botanical varieties:	Horticultural varieties
Cantaloups and Persians (var. *reticulatus*)	Cantaloup PMR 45 PMR 450 Others: PMR 5, PMR 6, V 1, SR-91, Campo, Jacumba Persian Persian Pershaw
Winter melons (var. *inodorus*)	Honey Dew Casaba Golden Beauty Crenshaw Santa Claus

Cantaloups and Persians have medium-sized fruits, with corky, netted surface, shallow sutures, aromatic fruit flesh that may be green, but more often is orange or deep salmon-orange. Winter melons have large fruits, with smooth or wrinkled skin (not netted), and green, white, or pinkish, nonaromatic flesh. Winter melons can be stored for a month or more after harvest. Generally, cantaloups and Persians produce an abscission layer between stem and fruit at maturity, the so-called "slip." No such abscission layer is produced by winter melons.

Cantaloup

Development and release of variety PMR 45 in 1936 and improved refrigeration techniques have made it possible to harvest fully mature California-grown cantaloups and deliver them in good edible condition not only to local markets, but to New York and other eastern seaboard markets. The important character here is firm flesh that does not soften or deteriorate rapidly after harvest and thus makes distance transportation feasible. All new varieties must have this character to be successful. In addition, the fruit in cross section should have a small, dry seed cavity, with thick, salmon-orange flesh, firm but not rubbery.

Consumers in this country have come to expect cantaloups of medium size,

round to slightly oblong, nearly covered with net (not coarse), and with slight aroma. Small, runty, misshapen, or shrunken melons, and those that are mottled or only partially covered with net, are likely to come from underdeveloped or diseased vines, and will not have the sugar content or flavor of fruits from healthy vines. The stem scar should look like a clean concave cup; there should be no trace of the stem adhering to the fruit. Parts of the stem remaining with the fruit indicate that it was harvested prematurely, and will never have the quality of a fully mature, vine-ripened fruit. Shaking, squeezing or smelling the fruits are not reliable indicators of quality. In fact, there is no fool-proof method of choosing a good edible cantaloup except to cut and taste it. The suggestions mentioned above can only improve the chance of a good selection.

Eastern varieties do not perform well in California and are not suitable for shipment to distant markets; therefore, they are not discussed in this circular.

Almost all cantaloups grown for market in California are of the Hale's Best group of varieties. The variety, Hale's Best, originated in the Imperial Valley near Brawley, introduced in 1924 by I. D. Hale, who obtained the seed from a nearby Japanese grower. Its origin is uncertain but probably comes from a chance hybridization of Pollock 10–25 and either the variety Emerald Gem or Perfecto. The original strain of Hale's Best was not very uniform for size, shape and other characters. But within a few years, by simple mass selection, seedsmen were able to introduce good uniform strains, each with a few distinct characteristics, but of the same general type. Examples are: Hale's Best 36, Hale's Best 936, Hale's Best Jumbo Strain, and Seed Breeders. As a rule, the Hale's Best varieties have soft flesh which makes them unsuitable for distance transportation. Soft flesh, however, can be a desirable character for local markets or for processing.

PMR 45 was introduced in 1936 by Jagger of the USDA and Scott of the University of California. Except for a small acreage in the Imperial Valley, nearly all of the cantaloup crop in California at the present time is of this variety. PMR 45 is resistant to race 1 of powdery mildew, but not to race 2. For this reason it should not be planted where race 2 of the fungus is prevalent.

PMR 45 is a Hale's Best type cantaloup, but with firmer flesh. The fruits are slightly oblong, 6″ × 5″, weigh 3 to 5 pounds, and are covered with moderately coarse net. The sutures are shallow and only partially netted. The flesh is firm, thick, salmon-orange; the seed cavity is small and dry. Under good growing conditions the vines are vigorous enough to cover the entire bed and provide plentiful shade for the developing melons.

The development of PMR 45 is one of the most interesting, important, and successful endeavors in the long history of

PMR 45—a slightly oblong cantaloup with good, over-all net, relatively thick salmon-orange flesh, and small dry seed cavity.

plant breeding in this country. In 1925, powdery mildew (*Erysiphe cichoracearum* DC)[1] suddenly widely infected cantaloups and other muskmelons in the Imperial Valley. After an intensive search for muskmelon material resistant to powdery mildew, resistant material was obtained from India by J. T. Rosa of the University of California in 1928. This material had none of the desirable characteristics of modern cantaloup. The melons were large, oblong, smooth, sutured, with thin skin, and cracked at maturity. The flesh was whitish, dry, mushy and tasteless.

It turned out that resistance was controlled by a single, dominant gene. The problem was to transfer this gene for resistance to a Hale's Best background. A plant of the original resistant material was crossed with one from a good strain of Hale's Best. In the second generation a resistant selection was back-crossed to Hale's Best. In the third generation from this back-cross, a large resistant population was grown, mass selected, and the seed distributed as PMR 50. This variety was grown to a limited extent for several years, but the melons were variable in size, shape and quality. Selection in large populations of resistant plants for four additional generations produced a resistant population with melons of good appearance and quality, and of uniform size and shape. Mass selection in this population produced seed of PMR 45, released to seedsmen in 1936.

The release of PMR 45 revolutionized the cantaloup industry in the western United States. It was the first variety of cantaloup that could be harvested when mature (full-slip), yet arrive in Eastern markets in good edible condition. Marketing of mature fruit of good quality created a vastly increased demand for the product.

PMR 45 proved to have sufficient genetic variability to be adapted to a wide range of environmental conditions. Thus, extensive plantings on the west side of the Central Valley of California extended the marketing period of California cantaloups from July through October. Now, almost 30 years after it was introduced, PMR 45 remains by far the most widely grown variety of cantaloup in this country—truly a remarkable plant breeding exploit.

PMR 450 originated as a selection from an inbred line of PMR 45. PMR 450 is similar to PMR 45 except that the vines are larger and more vigorous, and the fruit is larger, and tends to be less uniform in size and shape. PMR 450 is planted on a limited scale in localities where PMR 45 does not mature fruits early enough or large enough to be desirable.

Others. PMR 5 and PMR 6 are resistant to races 1 and 2 of the powdery mildew fungus. They belong to the Hale's Best group, but have been virtually discontinued because they are severely damaged by cucurbit viruses, particularly watermelon mosaic virus. Two other varieties of the Hale's Best type, V-1 and SR-91, have been grown intermittently but not very extensively in certain areas of California. They are resistant to sulfur, and can be dusted with this material to control powdery mildew. They are grown only where powdery mildew is a problem. The exterior appearance of the fruit is good, but the flesh is inclined to be soft and watery, and the fruit reacts unfavorably to distance transportation and subsequent shelf-life in retail outlets.

Muskmelon breeding programs are under way by University of California personnel in cooperation with several state experimental stations and the USDA. The primary purpose of these programs is to develop varieties of cantaloups resistant to powdery mildew and some of the virus diseases, yet adapted to culture in the low-elevation, arid, inland valleys of California and Arizona. Considerable progress has been made toward these objectives. Campo and Jacumba, released in 1964 by the University of California, the University of Arizona, and the USDA, combine powdery mildew resistance and moderate resistance to downy mildew, with some tolerance to crown blight. These varieties are similar to PMR 450 in vine and fruit characters.

Recent surveys have shown watermelon mosaic virus to be the most widespread and damaging disease of muskmelons in the desert areas of California and Arizona.

[1] There is some reason to question whether the organism is actually this species; see p. 21.

Persian—a large, round, globular muskmelon with orange flesh. A fine, thin net covers the entire fruit.

Resistance to the disease has been found. Not unexpectedly, the resistant parent has few of the desirable characters of a marketable cantaloup. Progress is being made in the tedious, time-consuming and intricate task of crossing, back-crossing, selection, and testing necessary to develop a commercially desirable fruit, while retaining resistance to mosaic.

Persian

Persian is a late-maturing local-market muskmelon, but with careful packaging it can also be shipped to distant markets. It is well adapted to culture in the Central Valley of California. This variety was presumably introduced into California by Armenians or people of Armenian descent. The vines are vigorous, coarse, with large, heart-shaped leaves. The fruits are large, 6 to 7 pounds, globular, 6″ to 7″ in diameter, and completely covered with fine net. The skin is grayish-green, turning to brownish when table ripe. The flesh is thick, bright pale orange, with smooth texture and a distinctive, bland flavor. The stem develops an abscission layer, separating it from the fruit at full maturity. Usually, however, the fruits are too soft to ship if they are picked at full-slip. As a result the fruits are harvested just as they commence to lose their gray-green color. Persians require a fairly long growing season to mature (100 to 110 days). Some small-fruited strains of Persian (4 to 5 pounds) have been grown from time to time. Persians are usually packed in a one layer "flat," nested in excelsior, 6 to 8 melons per flat.

Golden Pershaw, like the Persian, is a late-maturing muskmelon (about 115 days to reach maturity). It apparently originated as a chance hybrid with Persian as a pollen parent in a field of the winter melon, Crenshaw. After seven years of self-pollination and selection, Pershaw was released by the University of California Agricultural Experiment Station in 1952. The vines are large and vigorous, similar to those of Crenshaw. The fruits are large (8″ × 8″), globular and weigh 8 to 10 pounds when mature. At maturity, the fruits are golden yellow, free from sutures, with fine, thin net similar to that of Persian but more sparse. The fruits develop an abscission layer at maturity (slip) and, unlike the fruits of Crenshaw, do not sunburn easily when exposed to full sun. The flesh is peach-colored, thick, sweet, and has texture and flavor similar to Crenshaw. The cavity is dry, but the flesh surrounding it becomes soft and watery when overmature. The fruits should be harvested just before "full-slip," or they may deteriorate in transit. The variety is adapted to culture in areas where Persian and Crenshaw are successful.

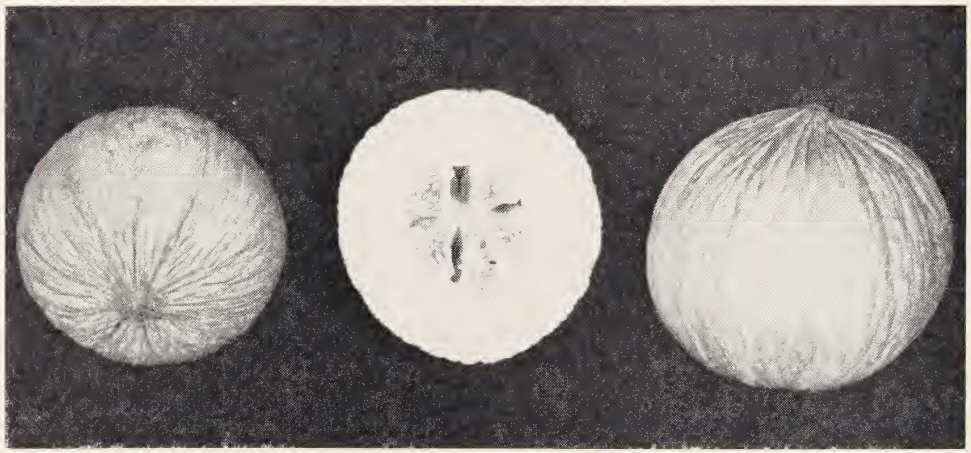
Honey Dew

Honey Dew has been grown in France for many years as the variety White Antibes. It was introduced into this coun-

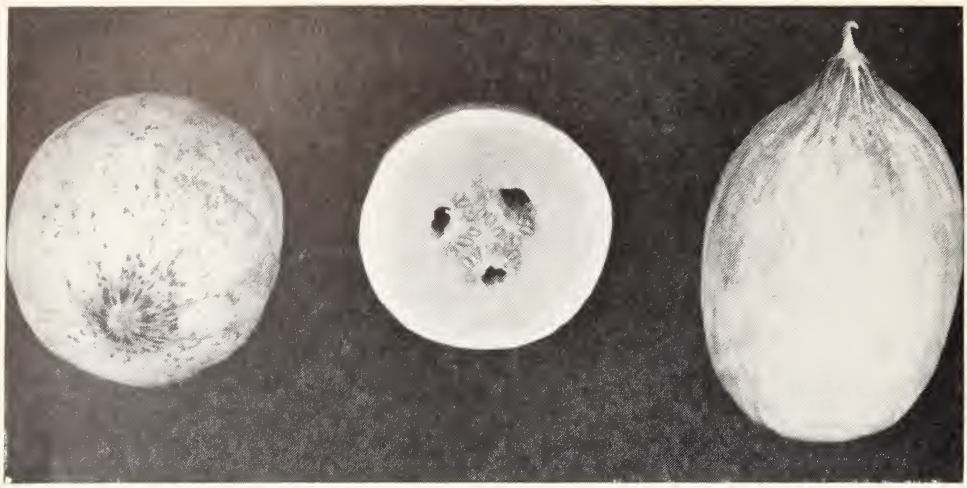
Honey Dew—a smooth, round muskmelon with white skin, but no net. The flesh has a greenish tint, is firm but juicy.

try in 1911 and, as Honey Dew, has become a popular late-season variety, especially among people originating in the Mediterranean area and the Middle East. It appears to be exceedingly stable genetically, and has remained essentially unchanged since its introduction, even to the extent that no well-defined strains have emerged. Vines of Honey Dew are vigorous, prolific, and have large leaves and stem. The fruits are 6″ to 8″ long, slightly oval to nearly globular in shape, and weigh 6 to 7 pounds. They are white skinned, smooth and hard, usually with little or no net. The flesh is green, juicy, sweet and tender. Honey Dew requires a frost-free season of 110 to 115 days to mature. Maturity is judged by a perceptible change in skin color from pale blue-green to ivory or cream, and by slight yielding at the blossom-end of the fruit under firm pressure from the thumb. No abscission layer develops between fruit and stem in this variety.

The Florida Agricultural Experiment Station has introduced a Honey Dew type variety called Floridew. This variety develops an abscission layer (slips) at harvest maturity. It is reported to be highly resistant to downy mildew. The fruits are smaller than the standard Honey Dew. The flesh is light green and thick; total



Golden Beauty Casaba—a round, globular muskmelon characterized by a wrinkled exterior, absence of net, and white, juicy, aromatic flesh.



Crenshaw Casaba—an oblong muskmelon, wrinkled near the stem end, with smooth yellow skin, speckled with green, but with little or no net. The flesh is thick and peach-colored.

soluble solids are reported to exceed 15 per cent. Whether Floridew will be suitable for culture under California conditions is undetermined.

Casaba

Golden Beauty is a typical casaba-type muskmelon. It was probably introduced into this country in 1878, but did not become popular until 1909 when the San Joaquin Valley Melon Growers Association shipped several carloads to Portland, Oregon. Vines of Golden Beauty are heavy, coarse, vigorous, and have large, deeply lobed leaves on stout petioles. The vines collapse under excessively high temperatures, especially during the harvest season. Golden Beauty is extremely susceptible to powdery mildew, and is often severely damaged by this disease. The fruit is globular, pointed at the stem end, 6″ to 8″ in diameter, and weighs 4 to 7 pounds. The rind is golden yellow at maturity, with longitudinal wrinkles but it has no net, and is easily bruised. The flesh is thick, white, juicy, and sweet, and has the distinctive casaba texture and flavor. No

Santa Claus Casaba—a large, oblong or oval muskmelon, with bright yellow, smooth skin splotched with dark green areas. The flesh is thick and white, with typical casaba flavor.

abscission layer is developed between fruit and stem. Again maturity is judged by a slight indentation at the blossom-end by pressure from the thumb. It requires from 110 to 125 days to mature.

Crenshaw is a casaba-type muskmelon of unknown ancestry. It may have been imported from the Middle East since similar types are quite common in this area. It was grown for the first time in California about 1939. Since then it has become very popular as a local market muskmelon in the Central Valley. It can, however, be shipped to distant markets if careful attention is given to harvest and packing procedures. The vines are large and vigorous, with dark green leaves and stout runners. The fruits are smooth, with a soft rind that turns bright yellow at maturity. They are globe-shaped, pointed, and slightly wrinkled at the stem end, 4 to 6 pounds in weight, 6″ to 7″ long. The soft flesh is pale pinkish, thick and juicy, and has excellent flavor. The vines collapse easily from excessive heat and from trampling they may receive at harvest time, and the exposed fruits sunburn quickly. For this reason growers plan to harvest only once or as few times as possible. Like other casaba-types it requires a long season (110 to 125 days) to mature properly.

Santa Claus is a casaba-type variety of minor importance. It has the typical large, coarse, casaba-like vines. The fruits are cylindrical, 10″ to 12″ long, 6″ or more in diameter, and more or less pointed at both ends. The skin is mottled with dark green diffused stripes, interspersed with bright yellow patches. The skin surface is nearly smooth, but there is a trace of net. The flesh is similar in color, flavor and texture to that of Golden Beauty. The fruits weigh 8 to 9 pounds, are edible in 110 to 120 days, and can be stored for late-season use.

SEED PRODUCTION

The muskmelon seed crop is usually produced in areas where the crop grown for the fresh market is unimportant. The Marysville-Gridley-Biggs district in the Central Valley of California has long been one of the principal seed producing areas of the United States. Seed grown there is likely to be free from seed-borne diseases that are troublesome in the East and South, except for the squash mosaic virus. Planting is normally done in May for harvest in September–October. Muskmelons grown for seed have much the same cultural requirements as the crop grown for the fresh market.

The importance of good quality seed, purchased from a reliable seed firm, cannot be overestimated. The cost of seed is a relatively minor item in the overall expense of producing a crop of muskmelons. Skimping on either seed quality or seed quantity can be highly unprofitable.

All forms and varieties of muskmelons are cross fertile, and progenies from succeeding generations suffer only moderately reduced fertility, if any. For example: all varieties of cantaloups will cross readily with Honey Dew, Persian, Casaba, and also with such unusual varieties as Snake Melon, Conomon, etc. Likewise, Honey Dew will cross with Persian, Casaba, Snake Melon, Conomon, etc. The domestic honey bee is the normal pollinator of muskmelon flowers. Pollination by other insects, wind or rain is insignificant. Isolation, therefore, is important in maintaining varietal purity. Separate any two varieties of muskmelons raised for seed by 1 mile or preferably 2 to 3 miles. Muskmelons, however, can be grown side by side with varieties of cucumber, watermelon, squash, or pumpkin without danger of contamination.

Careful roguing is essential for the production of quality seed. Roguing of off-type plants early in the season will prevent contaminated pollen from entering the seed field, and roguing just before harvest will help prevent seed from off-type melons entering commercial channels. Vines with fruits obviously off-type for the variety, and those with small, poorly dveloped fruits should be destroyed. Diseased plants likewise should be removed. Squash mosaic virus is carried through the seed. For this reason it is best

to destroy plants with mosaic symptoms.

Most of the muskmelon seed grown in this country is harvested with a mechanical extractor. The economics of muskmelon seed production unfortunately make hand-cutting and seeding of individual melons too costly to be competitive. Use of a mechanical harvester does not allow selection for flesh characters, while hand-cutting would permit selection for flesh color, flesh thickness, premature breakdown of the flesh, small cavity, loose seed and other internal characters. Mechanical harvesting, therefore, places a heavy burden upon the purity of the stock seed. Seed producers should develop a stock seed program adequate to cope with this problem, possibly by mass selection using hand-cutting to obtain a selected seed parent stock.

Recent studies show that only mature, "full-slip" melons should be harvested for seed. Seed from young, immature fruit and even from well-netted fruits that have not reached the "full-slip" stage of maturity germinate poorly. Fermented seed and mechanically harvested seed are about equal in germination if mature, "full-slip" melons are used. Surprisingly, fertilizer extremes had no effect upon seed germination, nor did the several steps in mechanical harvesting and artificial drying, if care was taken to avoid injury and too high drying temperatures.

CULTURAL OPERATIONS

Soil Preparation

To insure successful melon culture, prepare the soil carefully: work it when moist enough to be friable but not so moist that it puddles or is compacted. If it is too dry, irrigate and leave it until it retains just enough moisture to be thoroughly pulverized.

Flat land that was in seed or cover crops the preceding year should be plowed during the summer or fall to allow ample time for decay of any rough material which is turned under. Land previously planted to alfalfa can be successfully prepared by a shallow (6″ to 8″) plowing, followed by double disking and a deeper plowing within two or three weeks. Land previously in row crops should be disked and plowed as soon as the crops are harvested.

Make final preparations about a month before planting, so the soil can settle into a firm seedbed. At this time the soil should be disked, harrowed, and leveled or floated. If the soil is not well pulverized, the operation can be repeated. An implement designed for pulverizing the soil (in use in Kern County) is shown on page 13.

Land for irrigated crops must be leveled, with a slope of 3″ to 12″ per 100′ of row, to allow uniform penetration of irrigation water along the entire length of the row without excessive amounts of tail water. The slope should be greater in light sandy soils than in heavier soils. In a hillside field it is desirable to have the rows follow the contour as closely as possible, in order to form a desirable slope along the full length of each row. If after preparation, the surface soil is too dry to permit rapid seed germination and emergence of young plants, make irrigation furrows and fill them with water.

Raised-bed preparation. In early districts where the plants are grown on beds, the preliminary operations are the same as for flat-land planting. Generally about a month before planting, form the flat land into beds 2′ to 2½′ high and from 6′ to 7′ from center to center. Construct the beds to extend east and west, so their southern slopes will be exposed to the winter sun. To construct the beds, several methods can be used. A large lister, essentially a two-bottom plow, forms one-half of a bed at a time, or a tractor pulling six plows can be used to make two half-beds in a single operation. The south side of the bed is harrowed and smoothed with a V-drag. The bed is then ready for planting. Growers have devised implements which perform two or more operations at the same time. Some types of equipment and various steps in bed formation are pictured in the illustrations on page 13.

Soil preparation—implement used in Kern County for pulverizing the soil before the beds are formed.

Soil preparation—equipment used for forming muskmelon beds. Four beds are shaped in a single operation.

When you plant late muskmelons after a fall or winter lettuce crop, double-disk the lettuce beds to flatten the land and construct beds at once.

Fertilizer

Fertilizer practices in muskmelon culture depend upon the soil type and the amount of nutrients it contains. Most soils on which muskmelons are grown in California are low in organic matter, and many are low in nitrogen and phosphorus.

Muskmelons grow best on soil well supplied with organic matter, which can be provided by animal manures if available at a reasonable cost. In the Imperial Valley 10 tons per acre of steer manure has given good response. Apply manure before plowing or disking and ahead of the first irrigation. It should have a chance to decompose before planting. If animal manure is not available, organic matter can be supplied by plowing under such soil-improving crops as alfalfa, clover, cowpeas, soybeans, or sesbania.

Much of the muskmelon crop is grown without manure, but commercial fertilizers are nearly always necessary for successful large-scale production. Experimental evidence has shown that muskmelons should receive 60 to 120 pounds of nitrogen per acre and 25 to 50 pounds of phosphorus (60–120 pounds of P_2O_5).

Nitrogen. The nitrogen is usually applied in split applications—one-half just before or at planting and one-half side-dressed when the plants commence to form runners. Apply dry fertilizer, containing half the required amount of nitrogen, with a fertilizer drill a few inches to the side and a few inches below the seed. Equivalent amounts of liquid fertilizer containing nitrogen can be included in the irrigation water.

Phosphorus. Apply phosphorus early, preferably at or before planting, and in a single application. In some areas it is customary to broadcast the phosphorus just before bedding. Experiments show that phosphorus is four to five times more efficient when banded than when broadcast; that is, 10 pounds of phosphorus banded will give the same results as 40 pounds broadcast. Liquid fertilizers containing phosphorus are equally as effective as dry fertilizers when used in the same manner. Do not apply phosphorus fertilizer in irrigation water, because it is readily fixed in the soil and may not leach into the root area. Fertilizers such as 11-48-0 or 16-20-0 that contain nitrogen and phosphorus can be used to supply all or part of the nitrogen and phosphorus requirements.

Others. Most muskmelon soils in California contain an abundance of potassium. The use of potassium and of complete fertilizers is not recommended without preliminary strip tests. In such tests fertilizers containing potassium are compared with those lacking potassium but containing equivalent amounts of nitrogen and phosphorus.

There is no experimental evidence to indicate the need for any of the trace elements in muskmelon culture in California. The availability of these elements in the soil is often modified by cultural practices. For example, some of the trace elements may become unavailable in soils frequently given heavy applications of phosphate fertilizers. Only small quantities of these elements are needed by plants; excessive amounts are likely to cause severe plant injury. Apply trace elements to only a few plants in the field on a trial basis before treating an entire field.

Plant tissue analyses have been used effectively to evaluate the nutrient requirement of muskmelons. The concentration of nitrogen, phosphorus and potassium decreases with plant maturity to the degree that it is necessary to relate plant composition with the age of the plant. Excellent results have been obtained with petiole samples of a recently-matured leaf (approximately the sixth leaf from the tip of the runner). An evaluation of samples taken at the time of fruit set allows for the following classification based on dry weight:

Nutrient	*Safe level*	*Deficiency level*
NO_3–N	10,000 ppm	5,000 ppm
PO_4–P	3,000 ppm	1,500 ppm
K	4 per cent	2 per cent

Plants below the levels listed as deficient will have reduced yields. The same

levels can be applied to cantaloups, Persians. Crenshaws, and Honey Dews. Analyses of leaf blades cannot be used with the same degree of precision as noted for the petioles. Concentrations of nitrogen, phosphorus and potassium in the leaf blades are usually about one-fourth as high as in the petioles.

Planting

Spacing. In the early districts muskmelons are usually planted in single rows on the south side of raised beds spaced from 6′ to 7′ from center to center. Place the row on each bed just above the irrigation water line. The hills within the row are usually spaced 18″ to 24″ apart if covers are used to protect the young plants. If covers are not used, the hills can be spaced approximately 12″ apart. The wider-spaced hills are later thinned to two plants and the closer spacing to a single plant.

In the later districts where most of the planting is on the flat, and the plants become larger and produce more fruits than in the early districts, it is the custom to space the hills 4′ to 5′ apart in rows 5′ to 8′ from center to center. Hills are later thinned to two plants per hill. If planted in rows with a power-drill planter, the plants are thinned to be 24″ to 30″ apart.

Amount of seed. A pound of muskmelon seed contains 12,000 to 20,000 seeds. If 10 seeds are planted per hill, it takes about 2¼ pounds to plant 1 acre at the 24″ spacing in the early districts, and 3 pounds for the 18″ spacing. Three to 5 pounds of seed per acre are used in power-drill planters at all locations.

The number of pounds of muskmelon seed required for each acre of cultivated land can be calculated from this formula by counting a small sample to determine the number of seeds per pound.

Depth of planting. Plant muskmelon seed at depths ranging from ½″ to 1½″. The optimum depth depends on variety, type and condition of soil, and season. Large-seeded varieties can be planted deeper than small-seeded ones. Plant seeds deeper in light sandy soils and in cloddy soil, than in heavy or well-pulverized soils.

$$\frac{43{,}560}{\text{Row width} \times \text{spacing in row (ft)}} \times \begin{matrix}\text{Number}\\ \text{of seeds}\\ \text{per}\\ \text{hill}\end{matrix} \div \begin{matrix}\text{Number}\\ \text{of seeds}\\ \text{per pound}\end{matrix} = \begin{matrix}\text{Pounds}\\ \text{of seed}\\ \text{per acre}\end{matrix}$$

Muskmelon beds smoothed and planted; next the field will be irrigated.

Grower-devised implement for smoothing and planting muskmelon beds. Two beds are smoothed and planted in a single operation.

Plant them deeper late in the season, when the surface soil dries rapidly, than in winter or early spring, when the soil is cool and moist.

Muskmelon seed can be planted in prepared land with a hoe, a hand corn planter, or a power drill. Hoe planting (using a short-handled hoe) is a relatively slow method but widely used in the early districts. One man can plant about 1 acre a day. Cultivate the soil deeply with the hoe in a 10″ to 12″ area. Form a hole about 6″ long, 4″ wide, and 1″ deep, flatten the soil surface and firm with the hoe. Scatter 8 or 10 seeds over the flattened surface and cover with 1″ of soil, and firm it with the hoe. Then cover the hill with a thin mulch of loose soil. Hoe planting permits the formation of a well-prepared seedbed at each hill. It also allows an excellent distribution of the seed, especially where two plants are to be grown in each hill. Hill planting is preferable where the hills are to be protected with paper covers.

Time required. One man with a hand corn planter can plant about 8 acres in one day. This tool does not pulverize the soil where the seeds are dropped but can be used to advantage in fields that have been worked into good seedbed condition with power tools. If the planter does not have a shoe to control depth of planting, one can be made from a piece of strap metal bent to form a right angle. The depth-control shoe can be drilled for adjustment to different depths and fastened with bolts to one side of the planter. A metal core can be placed inside the planter to improve distribution of seeds in the hill.

With a power drill one man can plant about 4 acres an hour. The operator should make sure the planter feeds regularly. Power-drill planting has the advantage of placing all the seed at a uniform depth and uniformly packing the soil. It distributes the seed evenly along the row and is preferable where plant covers are not used. It can be used for the covered crop but it is wasteful of seed; many of the seedlings will not be protected by the paper caps and will be killed by frost. To distribute enough seed under the covers to establish a perfect stand calls for the use of about 10 pounds of seed per acre.

Earliness. Recent evidence indicates that covering the seed row at time of planting with a band of petroleum mulch will mature the crop about five days earlier. The mulch is applied as a spray in a band 4″ to 6″ wide at the rate of 35 to 50 gallons per acre (rows 5′ apart). The mulch raises the soil temperature, conserves moisture, and completely prevents mouse damage.

The temperature of the soil is very important for a satisfactory stand of muskmelons. Experimental results have shown that at a soil temperature of 59°F it takes approximately 15 days from planting to the production of a normal seedling. At 68°F it takes approximately seven days, and at 77°F five days. At temperatures below 59°F seedlings germinate very slowly if at all.

The most important factor in the production of early muskmelons is the selection of the planting location. With the same cultural procedures, muskmelons mature in the Imperial Valley four or more weeks earlier than in districts farther north. Within a given area some locations may be warmer than others—i.e., areas protected from wind by hills or other natural barriers or on the southern slopes of hills. Light-textured soils which warm up early in spring also favor early production.

Covers. Maturity in the early districts

A commercial cantaloup field in the Imperial Valley; the plants are covered with glassine paper sheets. The east end of each cover has been raised to allow the plants more ventilation and light.

is hastened by planting the seeds on the southern slopes of high beds; it is hastened further by the use of paper covers to increase soil and air temperature adjacent to the plants. The covers also protect the seedlings from light frosts occurring in the southern inland valleys during the winter. Mild winter climate combined with these special methods enables growers to plant directly in the field in the early districts from November to January, and to have vigorous plants ready to bloom when frost-free weather allows removal of the covers in early March. Protected plants may be expected to mature two to four weeks earlier than unprotected plants.

The most generally used cover is a sheet of glassine paper ($18'' \times 20''$) supported by a wooden strip or a wire brace. Place the cover over the hill immediately after the seed is planted. Remove 1″ or 2″ of soil from an $8'' \times 12''$ rectangle around the hill. Bend a piece of 17-gauge wire 18″ to 24″ long to form an arch, and thrust the ends into the ground until the wire arches about 4″ above the ground and parallel with the row. Place the paper sheet over the arch and replace the soil so that it covers the edges of the paper. Galvanized wire or wood splints (bamboo) can be used several years, but new paper must be purchased each season.

The cost of covering one acre of muskmelons varies from year to year with the costs of labor and materials. Approximate cost in the Imperial Valley in 1963 was $54.50—$31.50 for labor, $21.00 for paper, and $2.00 for supports.

Adjust the covers for ventilation when the plant has one or two true leaves (at thinning). Open the cover slightly at the east end to provide ventilation and to harden the plants. As the plants grow and the weather becomes warmer, lift the cover higher and open the east end (or the end away from wind) wider to admit more light and air. After all danger of frost is past (about March 15 in the Imperial Valley, and later in other districts), remove the covers.

Several types of covers other than glassine sheets are available. Parchment and oiled paper are little used, because they admit less light than glassine. Rigid cones, hemispheres, and other shapes made from glassine, plastics, and other transparent

materials are available. These are self-supporting and can be put in place more rapidly than glassine sheets.

Certain drawbacks to rigid covers have been observed. They retain condensed moisture later in the day and are less easily adjusted for ventilation than glassine sheets. Limited observations of rigid covers in the Imperial Valley have shown that temperatures fluctuate more widely during night and day, and plant injury occurred more often than under glassine sheets. Alterations in the dimensions of rigid covers might correct these defects.

Rigid covers are more expensive than glassine sheets, but part of this is nullified by lower costs of labor for setting them in place and by their possible re-use.

Planting in greenhouse or hotbed. In some locations in mountain valleys or in the northern part of the state, late frosts are likely to be too severe for paper covers to give adequate protection. At such locations the frost-free growing period may be too short to grow crops of muskmelons economically from seed planted directly in the field. At such locations, muskmelons can be grown for home consumption and for local markets if the plants are started in heated greenhouses or hotbeds and transplanted to the field when danger of frost has passed.

Start plants in small pots or plant bands, with a single container for each hill in the field. This can be done by planting six to eight seeds in each container and thinning the plants to two after emergence. Sow seeds three to four weeks ahead of the transplanting date, to insure sturdy plants with three to four leaves when they are set into the field.

Suitable temperatures, adequate light and ventilation, and carefully applied irrigation water will produce rugged plants that will stand transplanting. Day temperatures of 75° to 85°F and night temperatures of 60° to 65°F are best for growing greenhouse or hotbed plants. Place the plants so that each receives as much light as possible. Adequate spacing and prompt thinning promote sturdy, vigorous growth. Ventilation of the greenhouse or hotbed helps to provide a dry atmosphere that will prevent parasitic diseases. To improve growth, completely remove hotbed covers during warm days. Irrigate the soil in the pots only to prevent severe wilting.

Handle the seedlings carefully when transplanting them. Muskmelons do not regenerate roots readily. Knock soil and root mass from the pot intact and set the plant carefully in the field position. Plant bands provide the advantage that the whole band, including soil mass and plants, can be placed in the soil without disturbing the roots.

Cultivation

The muskmelon is a comparatively shallow-rooted plant and the roots often spread farther than the vines. Cultivation must be shallow, particularly near the plants and after the vines begin to develop.

When you remove the cover for thinning and adjustment of ventilation, cultivate each hill and intervening space with a hoe, and the furrows, top, and north side of the beds with power tools. Flat-land plantings and uncovered beds should be cultivated with power-drawn implements as soon as the plants emerge. If the planting is to be irrigated, you can form new furrows with the same operation.

The use of power cultivators can be prolonged if vine lifters are used or if the plants are turned by hand. Be careful to prevent damage to the plants by either method. The stems are easily damaged and the leaf area can be reduced by careless handling. Young fruits may be damaged if dragged over the ground. As a result, the fruits are scarred or malformed at maturity and are not marketable.

Late in the season, remove weeds with a hoe or pull them by hand. About six machine cultivations and three or four hand hoeings are common practice in most California muskmelon areas.

Thinning

Plantings sown directly in the field should be thinned in two stages. When plants in widely spaced hills have one or two true leaves, thin them to four plants per hill. In closely spaced hills and in power-drill plantings leave only two plants

in each hill. If there is danger of disturbing the roots of the remaining plants, cut the plants you remove rather than pull them out. The first thinning in covered plantings is usually performed when the covers are initially adjusted for ventilation.

About one or two weeks after the first thinning, thin the widely spaced plantings again, leaving two, well-separated plants in each hill. Thin closely spaced plantings to leave a single plant in a hill. The highest yield of marketable melons is obtained when the spacing is approximately 12″ between plants in the row.

There is no evidence that vine or fruit pruning is beneficial. Allow plants to develop normally.

Irrigation

How often and how much to irrigate depends on the amount of available water the soil can hold, the depth and spread of root development, and the rate of water loss from the soil.

The depth, texture, and chemical composition of the soil determine its ability to absorb water. Light sandy soils usually hold the least water; clay loams and silty clay loams hold the most. Sandy soils generally require more frequent irrigation, and for shorter periods than do heavier soils.

Muskmelon roots will penetrate a deep, light-textured soil to a depth of 4′ to 6′, and will penetrate most of the soil between the rows to the same depth. Such soils should be wetted to a depth of 4′ to 6′ at each irrigation. The water is best applied in broad furrows, to wet as much soil as possible. In applying water after fruit set, use care to prevent the rotting of fruits by soil fungi. Muskmelon roots may fail to penetrate shallow or heavy-textured soils to a depth of 4 to 6 feet. Such soils need to be wetted only to the depth to which the roots penetrate.

The rate of water loss depends on the character of the soil, the plant cover, and climate. Light-textured soils lose moisture more rapidly than heavy-textured soils. Large plants take up through their roots and lose through their leaves more water than do small, young plants. Temperature, moisture content of the air, and wind movement affect both the rate of water loss by the plants and the rate of evaporation from the soil. For instance, high temperatures, low relative humidity, and rapid air currents, singly or in combination, increase the rate of water loss from the soil. The frequency of water applications required for best results will therefore vary with soil type, plant size, and weather conditions.

Experimental evidence has shown that excellent yields can be produced with comparatively infrequent irrigations if the soil is at moisture-holding capacity at planting time. If winter rains have not left the top 4′ to 6′ of soil at moisture-holding capacity, pre-irrigate in advance of planting to allow the top soil to dry for preparation of the seedbed. In the early districts it is customary to apply the first irrigation after the beds are formed. Water is allowed to run until the beds are completely soaked. When dry, they are mulched, shaped with a V-shaper, planted, then irrigated again to assure adequate moisture for good germination.

After emergence, water is often withheld until flowering, to avoid frost injury, to maintain soil warmth, and to promote early flowering. Some growers apply water at about the time the covers are removed. Moderate amounts of water are applied after the plants have set one or two fruits and then at two- or three-week intervals until harvest. During the harvest period water is applied briefly at weekly intervals to prevent excessive cracking of the soil, if necessary.

In the late-muskmelon districts, if the soil is full of water at planting time, ample soil moisture for maximum yields is provided by irrigation to fill the soil profile to a depth of 4′ to 6′ immediately after thining and once again about a week before initial harvest. Light soils may need more frequent applications of water.

Experimental evidence has indicated that "medium" irrigation is the most satisfactory. The time to irrigate can be readily checked by the use of soil moisture blocks. When the tension reaches 3.0 bars or three atmospheres at a depth of 16″, the field should be irrigated.

Irrigation experiments in the San Joaquin Valley suggest that excessive ir-

rigation increases the number of culls—particularly growth cracks—and produces an excess of oversize fruits. These experiments also indicate that the management of nitrogen fertilization and irrigation must be closely integrated. Heavy irrigation does not make up for lack of nitrogen; on the other hand, heavy applications of nitrogen are useless if the crop is improperly irrigated.

DISEASES AND THEIR CONTROL

Seedling Diseases

Young muskmelon plants may fail to emerge or the stems may rot at the soil surface soon after emergence. Seedlings attacked after emergence fall over, wilt, and die. Such seedling rots and damping-off are caused by fungi that inhabit the soil (*Pythium* and *Rhizoctonia*). They may cause poor stands of plants in cold or excessively wet soils. Such losses can be reduced by rotation with crops that are resistant to the muskmelon-parasitic fungi; resistant crops include most cereals, crucifers, and lettuce. Losses can be reduced further by treating the seeds with fungicidal dusts (Spergon 0.3 pound to 100 pounds of seed or Arasan 0.125 pound to 100 pounds of seed), by planting when soil temperatures are favorable for rapid emergence and vigorous growth (75° to 90°F), by planting the seeds at shallow depth (½″), and by avoiding excessive soil moisture at the soil surface.

Root Rot Diseases

The roots of older plants may be attacked by several soil-inhabiting fungi, such as *Fusarium, Macrophomina, Phytophthora, Pythium, Rhizoctonia, Sclerotinia,* and *Sclerotium.* Either the small feeder roots or the entire root system may be killed. Above-ground portions of the plants may be chlorotic (pale green or yellow) or exhibit progressive killing of mature leaves (crown blight). Severely attacked plants may be stunted and nonthrifty, or they may wilt and die. Some of the root rot fungi also attack the lower parts of the stem and runners in contact with wet soil. *Macrophomina phaseoli* produces a flat, black growth on the roots and lower stems and causes the disease known as charcoal rot. Similarly, *Sclerotinia sclerotiorum* produces a white, cottony growth and causes the disease called cottony rot.

Some root rot fungi, such as *Pythium irregulare* and *P. ultimum,* attack muskmelon roots in cool soils during spring and fall. They are most damaging in wet, poorly-drained soils cropped to muskmelons after plantings of cucurbits or other susceptible plants such as peas or spinach. Muskmelons should be rotated with alfalfa, carrots, cereals, crucifers, and lettuce in soils known to harbor *P. irregulare* and *P. ultimum.*

Other root rot fungi, such as *Fusarium solani, Pythium aphanidermatum,* and *Sclerotium sclerotiorum,* attack muskmelon roots in warm, wet soils. Warm-season crops of muskmelons should not follow alfalfa, cotton, cucuribts, sugar beets or other plants that are susceptible to the warm-soil pathogens. Summer and fall muskmelons in infested soils should be rotated with lettuce, cereals, and other resistant crops. The different species of fungi have different host ranges; ask your Farm Advisor to help you identify the root rot fungi in your field and to devise the most suitable rotation for your area.

Seeds harvested from infested fields may carry root rot fungi on their surfaces. This is especially true of *Fusarium* infested fields because that fungus attacks the fruits as well as the roots. Disinfect seed by soaking it for five minutes in 1–1000 mercuric chloride and rinsing well in water. MERCURIC CHLORIDE IS TOXIC TO ALL LIVING THINGS. HANDLE WITH CARE. DISPOSE OF THE USED SOLUTION PROMPTLY AND CAREFULLY. DRY THE TREATED SEED IN THE SHADE AND THEN PLANT OR IMMEDIATELY LABEL AND STORE IN A MANNER THAT WILL PREVENT INJURY TO CHILDREN OR ANIMALS. The mercuric chloride treatment does not protect the young plants from seedling diseases. Spergon, Arasan, and other seed protectants

should be applied after the mercuric chloride-treated seed has been rinsed and dried.

Leaf Diseases

Several fungi attack the leaves of muskmelons. These fungi cause chlorotic (pale or yellow) or necrotic (dead) spots; some fungi, such as powdery mildew, produce a visible growth on the surface. Some leaf parasites also attack the stems, flowers, or fruits but can be seen most easily on the leaves.

Powdery Mildew. The most prevalent leaf disease on muskmelons in California is powdery mildew. It is caused by a fungus, *Erysiphe cichoracearum,* that grows on the surfaces of the leaves and stems. The fungus absorbs nutrients through minute feeding organs that develop in living host cells.

Powdery mildew can be recognized by the powdery, white growth on the host organs. Infected leaves may remain alive for indefinite periods or they may die and become brown and brittle. Infected stem surfaces develop thin, corky scabs and cracks. Infected host cells die if the fungus is killed, so necrotic spots occur after rains or spray treatments destroy the fungus. Necrotic spots also occur on resistant varieties that are subjected to a constant "rain" of spores from nearby susceptible muskmelons, cucumbers, and squashes.

Severely attacked plants become weak and non-thrifty and produce few or no marketable melons. The fruits may be small or malformed or they may be normal in size and shape. Large melons from mildewed vines often have poor net and flavor and may be sunburned. These defects result from poor foliage. Collapse of foliage from the base of the plant upward (powdery mildew incited crown blight) starves the maturing fruits and exposes them to the sun's rays.

Powdery mildew is most prevalent in major producing areas during spring and fall. It is seldom troublesome in the desert areas during midsummer but it occurs in the coastal areas throughout the growing season.

Several powdery mildew resistant varieties of cantaloups are on the market. PMR 45 and PMR 450 are resistant to cantaloup powdery mildew race 1. They can be grown in areas where race 2 is not prevalent. PMR 5 and PMR 6 are resistant to both race 1 and race 2. They are, however, very sensitive to viruses and a crown blight of undetermined cause. PMR 5 and PMR 6 can be grown in areas where crown blight and viruses are not troublesome. The new varieties Campo and Jacumba are resistant to both races of the fungus and moderately resistant to downy mildew and crown blight. Their ranges of adaptation are unknown. For this reason they should be tried on small acreages in areas where powdery mildew is troublesome. All resistant varieties perform better if they are isolated from powdery mildew-susceptible cucurbits so that they encounter fewer spores. The performance of resistant varieties near susceptible cucurbits can be improved by treatment with 2 per cent Karathane dust.

Powdery mildew can be controlled with sulfur dust on Honey Dew and the sulfur-resistant SR-91 variety of cantaloup. However, even these varieties may be injured by sulfur during extremely hot weather. PMR 5, PMR 6, PMR 45, PMR 450, Campo, and Jacumba should not be dusted with sulfur.

Powdery mildew can be controlled in sulfur-sensitive, powdery mildew-susceptible varieties of muskmelons, and in sulfur-resistant types during hot weather, with 2 per cent Karathane dust.

Downy Mildew. Downy mildew has been one of the most destructive diseases of muskmelons in the Atlantic and Gulf Coast states for many years; but, until recently, it has been seen only rarely in California. This disease caused an estimated loss of more than a million dollars to fall muskmelons in Imperial Valley in 1963. This increase may have resulted from the more widespread summer irrigation of several crops in the Imperial Valley, and from weather factors that increased relative humidity during late summer and early fall.

Downy mildew is caused by an obligate parasite, *Pseudoperonospora cubensis,* that grows only on cucurbits such as cucumber, muskmelon, squash, and water-

Powdery mildew race 2 on PMR 450 in the field at La Jolla.

melon. The fungus is primarily a parasite of the mature leaves. It penetrates the host organs in the presence of free water from rain or dew and grows inside the host tissues.

If dry weather prevails after infection, the infected tissues die and become dry, brown, irregularly-shaped spots, often with yellow halos. Severely spotted leaves die and become brown and dry. Defoliation usually begins at the base of the plant and progresses upward, producing downy mildew-incited crown blight.

If humid weather prevails after infection, the fungus produces purplish brown, nearly black, sporangia (spore sacs) on the leaf, mostly on the lower surface. The sporangia are primarily spread by wind and rain. They are also spread by man and machines when the plants are wet from rain or dew. In the presence of free moisture, each sporangium germinates to produce several swimming "swarm spores." Each spore can start a new infection. Severely attacked leaves become erect and folded or puckered; they are purplish and chlorotic but soon turn brown and dry. Infection of all of the foliage in humid weather causes a general blight rather than a progressive crown blight.

Early infections by downy mildew may cause fruit drop, fruit stunting, poor net development, sunburn, and poor quality. Late infections just before harvest may reduce soluble solids content and flavor without affecting the appearance of the fruit.

Losses from downy mildew in muskmelons can be reduced by the following practices:

- Isolate production fields from one another and from other cucurbits
- Promptly plow abandoned fields to reduce fungus populations
- Grow plants widely spaced on raised plant beds and prune growth in irrigation furrows to promote good air circulation and rapid drying
- Irrigate infrequently and cultivate to maintain a dry soil surface
- Do not disturb the plants when they are wet from rain or dew
- Treat plants, when rain or heavy dew occurs, to cover all exposed surfaces with a dust containing 5 per cent metallic copper derived from basic copper sulfate or with maneb or zineb sprays or dusts mixed according to manufacturers' directions.

The possible value of crop rotation is

unknown. The varieties Rio Gold, Rio Sweet, Texas 1, Georgia 47, Smith's Perfect, Edisto, and Homegarden are resistant to downy mildew but none of them are suitable for culture in California; the new varieties Campo and Jacumba have not been tested sufficiently to be recommended for fall culture.

Target Spot. The fungus *Alternaria cucumerina* incites light brown target spots, with a concentric ring color-intensity pattern, on mature muskmelon leaves. Severely attacked leaves turn brown and dry, producing an Alternaria-incited crown blight. The disease flourishes in warm, moist weather and may become severe after summer rains. It occasionally causes moderate damage in the inner coastal valleys and on the southern coastal plain, but little damage in the important production areas in the inland desert valleys or the Central Valley of California. It can be controlled with captan, maneb, zineb, or ziram sprays or dusts mixed according to manufacturers' directions.

Gummy Stem Blight. The seed-borne fungus *Mycosphaerella melonis,* which also persists on plant refuse in soil, attacks muskmelon lower stems at the crown and in leaf axils, and upper stems in contact with wet soil. It incites dark, sunken spots and streaks which exude a dark, gummy ooze. The fungus also attacks leaves causing large, brown, often ragged spots mostly progressing from the leaf margin inward. Minute, black fruiting bodies, called pycnidia, occur in surface tissues of the affected plant parts. Gummy stem blight is of little importance in the major muskmelon production areas of California. Severe infections have been observed occasionally in small fields where muskmelons were grown continuously year after year. Crop rotation and seed treatment with mercuric chloride, as for Fusarium root rot, are recommended for its control.

Other Leaf Diseases. The warm, dry interior valleys of California are nearly free from leaf diseases that are important in other parts of the United States. Such diseases include target spot and gummy stem, described before, anthracnose, incited by *Colletotrichum orbiculare,* and Ascochyta blight, incited by *Ascochyta phaseolorum,* and usually, downy mildew incited by *Pseudoperonospora cubensis.*

Vascular Wilts

Muskmelon plants of all ages may be attacked by fungi that grow in the water-conducting vessels (xylem or wood) of the vascular system in the roots, stems, and leaves. These diseases are usually observed in mature plants. Attacked plants may be nonthrifty and chlorotic, they may wilt excessively during midday, or branches, and even the whole plant, may suddenly collapse and die. If the stems of such plants are cut, yellow- or brown-discolored streaks can be seen, especially at the nodes.

Bacterial Wilt. Bacterial wilt, incited by the bacterium *Erwinia tracheiphila* (carried by the cucumber beetle), usually enters the plants through beetle-chewed leaves. It progresses from the leaf veins through the petiole to the stem vascular system. It is controlled by insecticides applied to control the cucumber beetle vectors. This disease, important in the Northeast, has not been observed in California.

Fusarium Wilt. *Fusarium oxysporum,* a soil-inhabiting fungus, invades the muskmelon plant through the root and grows in the vascular system of the root and stem. It cannot be controlled with sprays and dusts. It is controlled in the eastern United States by growing Fusarium wilt-resistant varieties and by growing other varieties in soils that are free from the parasite. Fusarium wilt is not known to occur in California and resistant varieties are not needed. Fusarium wilt-resistant varieties are not resistant to Fusarium root rot, which is incited by a different species of Fusarium.

Verticillium Wilt. The soil-inhabiting fungus *Verticillium albo-atrum* also invades the muskmelon through the root and grows in the vascular system of the root and stem. Mature leaves on attacked plants become chlorotic, then wilt and die, producing a Verticillium-induced crown blight. The disease is favored by moderate temperatures and plants may persist or recover to some extent at high tempera-

tures (exceeding 100°F). The plants collapse and wither if moderate temperatures (70°F to 90°F) prevail. The fungus persists in the roots of plants that partly recover.

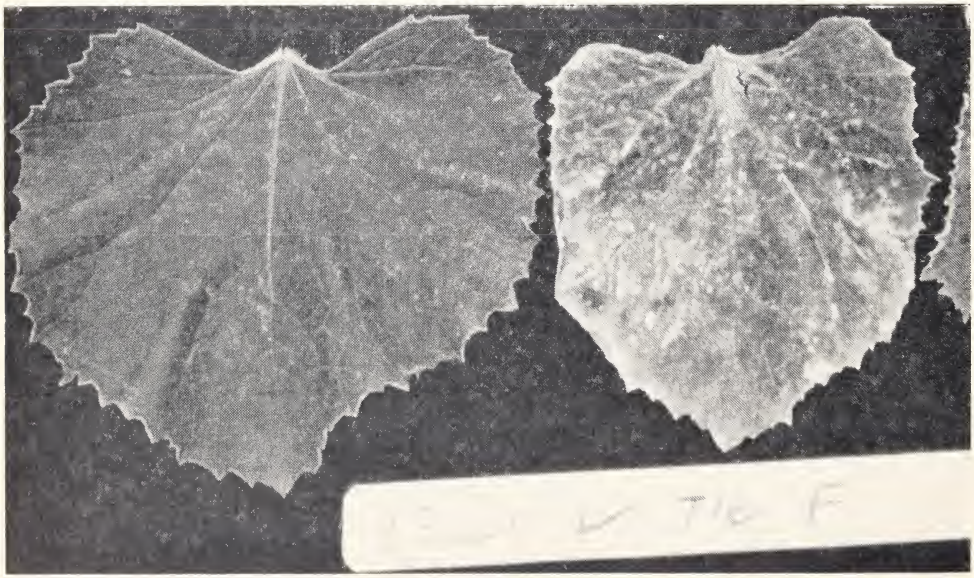
The fruits on Verticillium-infected plants may be dwarfed or stunted and drop prematurely, or they may be nearly normal in size. Normal-sized fruits on infected plants often have flat net, a dull color, and pale, insipid flesh with less than normal soluble solids content.

Verticillium wilt is common in Central California and causes moderate to severe losses in summer production areas. In addition to direct losses caused by low yields and large percentages of culls, indirect losses accrue from low consumer acceptance of fruits harvested from moderately diseased plants.

Muskmelon plant with Verticillium wilt.

Control of Verticillium wilt presents a difficult problem. *Verticillium albo-atrum* has a wide host range including several vegetables, small fruits, tree fruits, and ornamentals. Populations of the fungus are increased when any of these crops is grown. The fungus is able to persist in the soil for many years, even without a susceptible host, but the fungus population is reduced during culture of nonsusceptible crops such as cereals. The disease cannot be controlled with sprays or dusts. Cantaloups are less susceptible than Honey Dew and Casaba but no Verticillium-resistant varieties of muskmelons are available. Fusarium wilt-resistant varieties are not resistant to Verticillium wilt. At present, Verticillium wilt can be controlled only by planting muskmelons in soils free from *Verticillium*. It can be minimized by rotating muskmelons with cereals on infested soils to reduce the inoculum.

A healthy (left) and a WMV1-infected (right) muskmelon leaf. Note "blister mottle," distortion and accenting of serration.



Virus Diseases

Plants of all ages may show definite disease symptoms without rotting of the tissues, discoloration of the vascular elements, or visible parasite structures. Virus diseases are included in this category. The viruses become systemic, invading cells throughout the plant, and disrupt normal activities of the plant but usually do not kill it. They often cause chlorosis (pale green or yellow mottle), stunting, and distortion of the leaves; they weaken and stunt the plant; and they reduce yields. Viruses also lay the plants open to attack by other diseases.

Watermelon Mosaic Virus. The most troublesome virus disease of muskmelons in California is caused by a virus complex termed watermelon mosaic virus (WMV) because it infects watermelon. At least two distinct viruses in this group, currently named WMV 1 and WMV 2, are widespread in the early spring districts and cause severe damage every year. They occur elsewhere in the state but cause less severe losses. Both viruses are transmitted by aphids, especially the green peach aphid. Neither of them is seed transmitted. WMV 1 has a limited host range; WMV 2 attacks several hosts in addition to cucurbits.

Infected plants lose their crown leaves earlier than adjacent virus-free plants. Both viruses make plants susceptible to other parasites and to injury by adverse environmental conditions.

The viruses cause a blister-like, light green-dark green mottle, stunting, and distortion of muskmelon leaves. Stunting of young leaves without stunting of the stems may occur, producing a rat-tail appearance. These viruses also cause flower abortion, stunting, and malfunction.

Fruits that are set may look normal or they may be mottled, small, or misshapen. On severely affected cantaloup plants the net distribution on fruits is often disturbed so that ring patterns are produced. Fruit skin mottle is hidden by net on cantaloups but it can be observed on the smooth Honey Dew variety. It is increased by ethylene gas treatment applied to promote ripening of Honey Dew. Fruits that are not affected directly by the virus may be sunburned or they may ripen prematurely. Prematurely ripened fruits have low quality, and netted varieties have poor net. These indirect effects result from lack of sufficient foliage to cover and supply food to the fruits. Losses are slight if the plants are not infected until close to harvest, but severe losses may result if young plants are infected.

No satisfactory measures have been developed to control WMV 1 and WMV 2. Experimental attempts to control the aphid vectors were not successful. Once the virus enters a live host cell it cannot be destroyed without also destroying the host plant. The viruses apparently overwinter in summer squash and, perhaps, some unknown hosts. Additional knowledge about overwintering of the viruses may eventually produce a means of controlling them before they are transferred by aphids to muskmelons.

WMV-resistant varieties are not available, but the varieties PMR 450, Campo, and Jacumba are more tolerant to the viruses and suffer less severely than other varieties such as PMR 5 and PMR 6. The use of those varieties and cultural practices that promote plant vigor will reduce losses caused by watermelon mosaic viruses.

Cucumber Mosaic Virus. Cucumber mosaic virus (CMV) occurs in moderate frequency in muskmelons throughout the state. This aphid-vectored virus is not seed-borne in commercial cucurbits; but it has a wide host range and attacks several weeds, crop plants, and ornamentals that enable the virus to survive during periods when cucurbits are not grown. It is often most severe in spring plantings near towns where perennial ornamentals such as periwinkle serve as virus reservoirs. It may be severe, also, in muskmelons located near earlier plantings of susceptible crops such as muskmelon, summer squash, tomato, sugar beet, and safflower.

Muskmelons infected with cucumber mosaic virus are often affected more severely than are those infected with either WMV 1 or WMV 2. The leaves are chlorotic (light green or yellow), mottled, and all above-ground parts of the plant

including the stem are stunted. The plant or part of the main stem may be killed under certain conditions. Plants that survive may produce new, moderately affected growth from the crown. CMV-infected plants lose their crown leaves earlier than do adjacent virus-free plants. CMV also makes the plant susceptible to other parasites and to injury by adverse environmental conditions.

CMV reduces yields and delays fruit production. Fruits on diseased vines may be dwarfed or nearly normal in size. Fruits of normal size are often malformed, have poorly developed net, and are of low quality. Fruits that appear normal otherwise may be sunburned at maturity. Early infections often cause severe losses; late infections may have little measurable effect on yields.

No suitable controls for CMV are available. Sprays and dusts have no effect on the virus itself. Experimental attempts to control the insect vectors (green peach and other aphids) on muskmelons have had little effect on occurrence and severity of the virus. Weed eradication and the treatment of other crops such as sugar beets, to prevent aphid population buildup, apparently delay virus infections and improve yields in muskmelons.

No CMV-resistant muskmelon variety is available. Current breeding work is directed toward the production of CMV-resistant varieties. Until such varieties become available, muskmelon growers can reduce losses from CMV by avoiding areas near ornamentals. Muskmelons should be isolated, also, from earlier plantings of CMV-susceptible crops such as safflower, summer squash, sugar beet, tomato, and other muskmelons.

Squash Mosaic Virus. Squash mosaic virus (SMV) occasionally causes severe losses in minor production areas on the coast and in the Central Valley. Unlike WMV 1, WMV 2, and CMV, SMV is seed-borne and it is transmitted from one plant to another by cucumber beetles (both striped and spotted) but not by aphids. Its host range is limited to certain cucurbits; it does not infect watermelon.

Distribution of SMV appears to be associated with seed transmission and populations of spotted and striped cucumber beetles. Occasional plants with seed-borne SMV occur in all areas. In the absence of cucumber beetles, spread of the virus is limited to mechanical transfer by men and equipment and it usually does not become widespread in the spring and major summer production areas. In areas where cucumber beetles abound, they transfer the virus from a few plants with seed-borne infection to all or most of the plants in a field.

SMV causes leaf mottle and slows growth of muskmelons, and it also causes flower stunting and malfunction. Nectar production is reduced so that the flowers are less attractive to bees. Fruit set is reduced. Fruits that are set may be small, malformed, or nearly normal in size and appearance. Net development and flesh quality are often reduced. As with other viruses, late infections have little effect but early infections may cause severe reduction of fruit yield and quality.

SMV can be controlled by isolation of fields from susceptible cucurbits such as cucumber, pumpkin, squash, wild cucurbits, and other muskmelons, combined with the use of virus-free seed. Virus-free seed can be obtained by growing the seed crop in the lower desert valleys, and in other beetle-free areas, and roguing out mottled seedlings at the 3- or 4-leaf stage. Spread of the virus can be reduced by controlling spotted and striped cucumber beetles (see page 30).

Cantaloup Latent Virus. Cantaloup latent virus (CLV) is widespread in areas of spring muskmelons, but also is found elsewhere in California. It occurs in combination with other viruses (WMV 1, WMV 2, and CMV) in natural infections. Pure cultures of CLV usually cause no symptoms in cantaloup seedlings but they cause necrotic primary lesions on leaves of *Chenopodium amaranticolor,* a diagnostic host. CLV is transmitted mechanically and by aphids from one host plant to another. Its effect on muskmelons in the field is unknown.

Curly Top. Curly top virus (CTV) occurs in California muskmelons but widespread infections have not been observed in the major production areas. CTV is prevalent in the Salt River Valley of Arizona. This virus is not seed-borne

and it is not transmitted mechanically, nor by aphids or beetles. It is transmitted to muskmelons by the beet leafhopper from a wide range of host species. Low incidence of the disease in California apparently results from low population density of the beet leafhopper during the muskmelon season in production areas.

Unlike the mosaic viruses, CTV does not cause mottle symptoms. Muskmelons infected in the seedling stage usually die. Those infected at the 2- to 4-leaf stage may die or be stunted and produce no fruits. Plants infected later may exhibit no observable symptoms or they may be stunted at branch ends with leaves spaced close together. Late infection reduces fruit yield and quality and lays plants open to injury by other diseases and adverse conditions. Clean culture practices that reduce beet leafhoppr populations help to avoid curly top infections. Other control measures for CTV are not now needed in California.

Other Viruses. Fortunately for California growers, tobacco ringspot virus, prevalent in the Rio Grande Valley, occurs rarely or not at all on California cucurbits. Several other viruses, mostly unidentified, are observed in occasional plants. They are of little importance now, but changes in crops, farm practices, or weather could change their frequencies and make one or another of them a major problem.

Multiple Virus Infection. A plant infected with one of the viruses mentioned above is not thereby protected from infection by the others. Accordingly, two or more viruses may occur in a single host plant when virus infections are frequent. WMV 1, WMV 2, CMV, and CLV have been isolated from a single plant in Imperial Valley.

Multiple virus infections have greater effects on the plant than single infection by any of the components. The increased effect of multiple infections explains, in part, the faster plant deterioration and lower yields during seasons when virus infections occur early than during seasons when virus infections occur late.

The prevalence of several viruses in the early spring districts makes control by virus resistance a difficult problem. It will be necessary to combine resistance to WMV 1 with resistance to WMV 2, resistance to CMV, and, perhaps, with resistance to CLV to ultimately control the virus problem in Imperial Valley by means of resistance alone.

Other Plant Abnormalities

Salt Stunting. Muskmelons are very sensitive to high salt concentrations in the soil. Plants in excessively salty soils may fail to emerge, resulting in poor stands. Plants that do emerge grow slowly and their leaves, stems, and fruits are dwarfed. Yields are reduced in moderately salty soils in which dwarfing effects are not obvious.

Losses from salt injury can be avoided by planting in well-drained or tiled soils that have salt concentrations less than 4 millimohs.

Alternate-leaf Crown Blight. Mature leaves on muskmelons sometimes die from the base of the plant upward, with no observable fungus, virus, or insect. At first, only every second or third leaf along the stem is affected, but eventually most or all of the mature leaves die, starving the fruits and exposing them to the sun. The fruits slip from the vines prematurely, and they have soft rinds with poorly developed net, low soluble solids, and poor flavor.

The trouble apparently results from root pruning caused by various agents including root rot fungi that attack the small, hair-like rootlets, cracking of the soil associated with drying between irrigations, and suffocation of small rootlets during excessive irrigations and waterlogging in heavy soils. Drought causes a similar disorder, especially in light soils; but all of the leaves are affected in sequence, i.e., there is no pattern of alternating affected and unaffected leaves.

Leaf loss from crown blight is greatly increased by virus infections, by heavy fruit loads on the plants, and by plant maturity. Virus-free plants, low-yielding plants, and young plants are affected less severely than their neighbors.

Losses from crown blight can be reduced by:

- Planting on friable, fine-textured, well-

Muskmelon shoot with crown blight showing alternating diseased and healthy leaves. Diseased leaves are marked by arrows.

drained soils that can be irrigated thoroughly without waterlogging and dry slowly without cracking

• Avoiding soils known to harbor *Pythium, Phytophthora, Fusarium* and other muskmelon root pathogens

• Irrigating adequately to moisten the soil throughout the root zone but not so excessively that waterlogging results

• Planting in virus-free areas or during virus-free seasons.

Pesticide Injury. Muskmelons are very sensitive to many agricultural chemicals including several fungicides, insecticides, and weed killers. Pesticides are valuable to man because they kill harmful living organisms. But these substances may also harm crop plants. This is especially true of muskmelons.

The sensitivity of most cantaloup varieties to sulfur is well known. This pesticide kills the foliage of sulfur-sensitive varieties at moderate temperatures. It also causes spotting, bronzing, or scorching of foliage of sulfur-resistant varieties at high temperatures.

The powdery-mildew fungicide Karathane, the general insecticide parathion, and other pesticides also may cause bronzing of muskmelon leaves if excessive amounts are applied. Use only the smallest dosage that will control the pest you want to control.

Weedkillers such as 2,4-D, inadvertently applied to muskmelons, may kill the plants, stop growth, or cause distorted growth and reduction of flowering and fruiting. Some weedkillers decompose slowly in the soil. These may persist and be absorbed by muskmelons long after they were applied in the soil. They can also prevent emergence and inhibit growth so that the plants fail to produce fruits. Minute amounts may cause virus-like foliage and fruit distortion. Do not plant muskmelons on land treated with hor-

mone-type weedkillers until test plantings have demonstrated that the weedkiller has decomposed.

Fruit Rots

Fruit rots of muskmelon occur in the field, in transit, in storage, and in markets. Many of the decays on harvested fruits originate from infections initiated while the fruits were maturing on the plant. They occur most often on the fruit surface in contact with wet soil, but they may occur anywhere on the fruit surface during humid weather. Fruit rots occur, also, at the stem end of the fruit in varieties that separate naturally from the stem at maturity. Success of the western melon industry depends in part on the relative freedom from fruit rots in the dry desert areas.

Several filamentous fungi such as *Fusarium, Phytophthora,* and *Pythium* are the most common parasites that cause fruit rots in the field. Other filamentous fungi, such as *Rhizopus,* and bacteria, such as *Erwinia,* join them in rotting fruits in transit and storage. The organisms usually gain entrance through ruptures in the skin. Such breaks occur naturally on surfaces in contact with moist soil and elsewhere on the fruit following rains and heavy dews. They are caused, also, by rough handling during harvesting and subsequent operations.

Losses from fruit rots can be reduced by planting on raised beds, irrigating carefully, and cultivating the soil to maintain a dry surface for the fruits, especially during the harvest season; by moving fruits away from irrigation furrows; by prompt harvesting, refrigeration, and marketing; and by gentle and clean handling. Refrigeration at 40° to 45°F reduces losses from fruit rots.

INSECT AND MITE PESTS[2]

Cantaloups and other melons are often damaged by a number of insect and mite pests. These may attack the germinating seed or the plants at any time during growth. Attacks are often sporadic and seasonal, and control measures may not always be necessary. Under favorable conditions highly destructive pest populations can develop in a relatively short period of time. Pests may attack the underground sections of the plants or they may do damage to the plants above ground.

Root Pests

Wireworms. These long, shiny brown worms often attack the germinating seeds and seedlings during the fall, spring, or early summer. The most destructive species in the interior valleys is *Limonius cannus.* Control is accomplished by treating the seed or by fumigating the soil before planting.

Seed-corn Maggot. The seed-corn maggot, *Hylemya cilicrura,* attacks germinating seed of melons in the early season when the soil has not had an opportunity to warm up and is still wet. The seed can be protected by treating with an insecticide-fungicide preparation before planting.

Cutworms. Young plants are often damaged or killed by cutworms. These caterpillars usually hide in the soil under debris or under clods during the day. At night they come out to feed, cutting off the plants at or just below the crown level. Several different species of cutworms may damage muskmelons. If your infestation is localized, and only a few hills are damaged, you can merely replant. If, however, a considerable area is damaged, use insecticides.

The rough-skinned cutworm, *Proxenus mindara,* is becoming a serious pest of cantaloups in certain localities. The larvae cause scarring of the undersides of the melons. Baits have proven successful in its control.

[2] This section was prepared by W. H. Lange and A. A. Grigarick, Department of Entomology, Davis.

Leaf Pests

Melon Aphid. The melon aphid, *Aphis gossypii*, is one of the most damaging of melon pests. These small, green plant lice are first seen on young plants near the tips of runners or in growing points. They cluster in numbers on the underside of growing leaves, distorting and curling the leaves. A large amount of honeydew is produced and the melons become coated with a sticky secretion, producing an environment favorable for the development of a sooty mold. Several other aphid species cause similar injury. The end result is loss of vigor, stunting, or even death of the plants.

Spot control with insecticides when infestations first appear is often helpful. In applying insecticides, be careful to preserve the many natural enemies of the aphids.

Green Peach Aphid. In desert areas, watermelon mosaic virus is transmitted chiefly by the green peach aphid, *Myzus persicae*. This aphid moves into melon fields in large numbers from surrounding vegetation, especially sugar beets, and carries the mosaic virus as it moves from one plant to another. The green peach aphid does not breed on muskmelon plants. To date, insecticide applications have proved ineffective in checking the spread of this virus.

Cucumber Beetles. These common green and black beetles, some spotted and some striped, are familiar to every grower. The two common species are *Diabrotica undecimpunctata* and *Acalymma trivitta*. In southern California *Diabrotica balteata* and *D. undecimpunctata howardi* also occur. They fly readily and migrate into cultivated areas from alfalfa and uncultivated lands. They prefer the tender, succulent portions of the plants, chew the leaves full of holes, and scar the runners and young fruits. Scarring about the crown of the plant is typical of adult damage.

The larvae may cause serious injury by feeding on the roots. Young plants are often killed. Insecticide applications may be necessary against the adults.

Leafhoppers. These tiny, green, jumping insects often damage melons, especially late in the season. The most common species is the melon leafhopper, *Empoasca abrupta*. The leafhopper has sucking mouthparts and causes severe white stippling and yellowing of the leaves, green-spotting of the fruit, and premature leafdrop. Insecticide applications may be necessary.

Striped cucumber beetle adult.
Photo F. M. Summers.

Leafminers. The serpentine, white tunnels of leafminers, *Liriomyza* spp., often are seen in leaves of muskmelon varieties. These flies attack alfalfa, which is often a source of infestation, and various other cultivated crops and weeds. Occasionally they cause a drying of the leaves, resulting in sunburning of fruit and reduction in yield and fruit quality. Natural enemies usually keep it under control. Applications of insecticides may be necessary.

Red Spider Mites. Leaves attacked by mites become blotched with pale-yellow and reddish-brown spots. Eventually the leaves take on a pale, sickly appearance and gradually dry and drop. Examination of the leaves with a lens reveals numerous, minute pale-green, red or brown, eight-legged mites. Minute spherical eggs may be present as well as silk webbing. This webbing is often filled with cast skins, dust and other debris.

The species involved are the two-spotted spider mite, *Tetranychus urticae*,

the Pacific spider mite, *T. pacificus,* the Atlantic spider mite, *T. atlanticus,* the desert spider mite, *T. desertorum,* and the brown wheat mite, *Petrobia latens.*

Minor Pests. Muskmelons are also occasionally attacked by grasshoppers and crickets, earwigs, flea beetles, thrips, the cabbage looper, and other caterpillars. In recent years two armyworms, the yellow-striped armyworm, *Prodenia praefica,* and the beet armyworm, *Spodoptera exigua,* often damage the foliage and scar melons.

Special Notice

Inasmuch as insecticide and nematocide recommendations change periodically due to new research and differences in registration, consult the most recent Pest Control Guide (Cucurbits) for the latest controls. This is published by the University of California Agricultural Extension Service.

NEMATODE DISEASES[3]

Nematodes causing diseases in muskmelon in California belong in the root-knot group. Two species are commonly found and, if proper control measures are not followed, will cause severe damage and perhaps a complete loss of the crop. These two species are: *Meloidogyne incognita* (the Southern root-knot nematode) and *Meloidogyne javanica* (the Javanese root-knot nematode). A third species of root-knot, *Meloidogyne hapla* (the Northern root-knot nematode) is occasionally found infecting muskmelons in California and can be a serious problem. Other nematodes, besides the root-knot nematode group, are sometimes found on cantaloups but are of minor importance. Control measures applied for root-knot control are applicable to the control of other nematode parasites.

Symptoms

The above-ground symptoms of root-knot nematode damage to muskmelon are non-distinctive and consist mainly of varying degrees of stunting and moderate to severe chlorosis. The diagnostic symptom of root-knot damage occurs on the roots where single swellings or large galls occur depending upon the degree of infestation, host reaction, and age of the root (see photo). Upon close examination, one can see egg masses protruding from the galls. These are yellow-brown and approximately ½ to 1 mm in diameter. If you will probe into the root tissue directly under the egg mass, you will find a glistening white adult female root-knot nematode, about the size of the external egg mass. Once a muskmelon root system is heavily infected with nematodes, secondary organisms invade through the wounds. In a short time the entire root system breaks down and the plant dies. Frequently, young plants heavily infected with root-knot nematode will collapse shortly after an irrigation or rain because of the invasion of secondary organisms such as fungi and bacteria which thrive under moist soil conditions.

Control

Resistant Varieties. At present there are no commercial varieties resistant to nematodes.

Rotation. Rotations with non-host crops for at least one year will give a fair degree of control. Weed hosts, however, growing among the non-host crop will often support a sufficient population through the cropping period to render rotation for nematode control ineffective. Also, land used for muskmelon production often is of such high value that a rotation program with a non-host crop is economically unsound. If so, the most satisfactory means of nematode control is preplant fumigation.

[3] This section was prepared by John D. Radewald, Department of Nematology, Riverside.

Root-knot nematode damage to muskmelon roots (right); control plant (left). The large galls and single swellings on the roots are characteristic responses to the invasion of root-knot nematodes.

Chemical Control by Preplant Fumigation. Preplant fumigants for nematode control are applied as row or bed treatments, and give results as good as broadcast applications. Be extremely careful, however, to insure that proper soil moisture exists in the bed at the time of fumigation and that a good seal is obtained after the fumigant has been applied.

A conventional fumigation rig can be used by placing one or two chisels in the row area. Do *not* place the chisel (or chisels) in the immediate planting row, but rather 4″ to 6″ off to one or both sides, depending on whether one or two chisels are used.

No fumigants are currently recommended for use as postplant control measures for root-knot nematode on muskmelon. Nematode presence should be detected before planting and preplant fumigation should be used.

Fumigation for nematode control (see box on page 31) is most efficient when the soil is in *good seedbed preparation*, free of large clods and undecomposed plant debris. If plow soles or severe compaction exist, the soil should be subsoiled and then prepared as a good seedbed. *Good land preparation* is a prime requisite for a good fumigation job. *Soil moisture* at the time of fumigation must be at the highest level which permits good land preparation. In lighter soils this is usually at, or slightly above, field capacity; in heavier soils this may be slightly below field capacity. *Soil temperature* is another critical factor. *Immediately* after the fumigant is injected into the soil, it should be compacted and the shank marks closed. This is done with a ring roller or cultipacker. Go over the treated soil twice with the cultipacking equipment. If a ring roller or cultipacker is not available, a spring or spike toothed drag can be used. Drags are not as efficient, however, because the sole purpose of the operation is to close the soil surface to prevent rapid escape of the fumigant. Thus the roller or cultipacker will do the best job.

HARVEST AND POSTHARVEST OPERATIONS

Thorough attention to harvesting, packing shed operations, refrigeration, and timing is essential for the marketing of high-quality muskmelons. The fruits must be harvested at the proper stage of maturity. Afterwards, they must be handled rapidly, but carefully, from field to consumer. This section describes currently used methods and suggests possible improvements in the postharvest handling of muskmelons.

Harvesting

Determining Maturity. Cantaloups are harvested at the "full-slip" stage of maturity. At this stage, a thin abscission crack encircles the stem where it is attached to the fruit, and the melon separates easily from the stem. Melons harvested at less than "full-slip" maturity do not achieve their full potential for sugar content, flavor, texture, or aroma. After the fruit first attains "full-slip" maturity, cantaloup varieties used for shipping require post-harvest ripening to attain desirable eating quality (flavor and texture).

Other indexes of cantaloup harvest maturity include fruit color and appearance of the net (masses of corky, crisscrossed, heavily calloused tissue that erupts through the epidermis). At maturity the skin color changes from dark green or gray to light gray or yellow. In many cantaloup varieties skin color change coincides with abscission layer development and is used as a supplementary gauge of maturity. At maturity, the net becomes raised, rounded, and broader, covering more of the surface than on immature fruits.

Harvest maturity of Persian melons is determined primarily by skin color changes, because in this variety the abscission layer does not develop or is delayed until the fruit is overripe. The ground spot of Persian melons develops a pinkish color when the fruits are mature. This change in color of the ground spot serves as a good index of harvest maturity.

Honey Dew melons have achieved minimum-harvest maturity when they are well filled out and of normal size; the ground color is white, but with a greenish aspect. The blossom end is hard to firm; there is no aroma, and no waxy skin coating is evident. The surface may feel prickly or hairy. Such melons are not likely to ripen well without ethylene treatment.

With the Casaba variety, Golden Beauty, Crenshaw, and Santa Claus, an experienced operator can judge harvest maturity with surprising accuracy by applying firm pressure with the thumb to the blossom end. A slight yielding or softness indicates maturity. This test is not precise and requires considerable experience to be used effectively. Also, fruits of Crenshaw should have considerable yellow color when harvested. Full-green fruits of this variety are immature and of poor eating quality.

Harvesting Operations. Cantaloups are commonly harvested from 10 to 20 times from any one field during a season, depending upon various environmental and marketing conditions. In a study of ten Kern County cantaloup fields, Zahara (1962) observed that about 75 per cent of the melons were harvested from the fourth to tenth picks, with the largest volume harvested in a given pick occurring during the middle of the harvest season.

At the start of the season cantaloups are harvested once or twice a week. As the season progresses, harvesting is increased to every other day, and finally to daily, or even twice daily during warm weather. Honey Dew, Persian, and Casaba are generally harvested one to three times per week.

Harvesting begins early in the morning and continues until the acreage to be harvested is completed. Tests have shown that early-morning-harvested cantaloups are more susceptible to scuffing and less susceptible to bruising than are those harvested later in the day. Less refrigera-

tion is needed to precool melons harvested during cool morning hours. Generally, pickers work faster in the morning than in the afternoon.

Harvesting requires a large amount of hand labor. Two methods are used for cantaloups and Honey Dew. In the first method crews consisting of 15 pickers and a truck driver are organized into a unit. Each picker harvests cantaloups from a single row and places them in a picking bag carried on his back or side. He then carries the filled bag, containing 60 to 70 pounds of melons, to a field truck or trailer for emptying. When trucks are used, pickers walk up an inclined plank at one side of the rear of the truck, unload their melons, and return by a plank on the other side of the truck. Most field trucks and trailers haul 4 to 4½ tons of cantaloups per load. A few shippers use much larger trucks, especially for hauling melons from distant fields (30 to 40 miles from packing sheds). Cantaloup, Persian, and Casaba fruits are piled 2′ to 3′ deep in trailers and 3′ to 5′ deep in trucks. Sides and bottoms of the trucks and trailers are padded, commonly with old carpeting.

The second harvesting method uses various types of moving conveyors covering 10 to 20 beds, propelled or towed through the fields. With some types, pickers, working ahead of the machines, harvest the melons from two beds and windrow them in alternate furrows. Another crew follows the conveyor belt and loads the windrowed cantaloups onto the belt. With other types, the machines precede the pickers, each of whom selects melons from a single bed and places them on the conveyor. The conveyors unload the melons into field trucks or trailers which move through the field with them.

Capital invested in equipment, operating, and maintenance expenses makes the use of mechanical harvest aids more expensive than harvesting into bags. Mechanical aids lessen the worker's burden, help him save time, and reduce his energy requirement, but do not necessarily. increase his productivity enough to offset the cost of the equipment and its use.

Better training of pickers and teaching them to discard culls in the field might reduce hauling and handling costs, but culls left in the field tend to buildup insect troubles. Agricultural engineers and horticulturists at the University of California are working on a selective mechanical harvester for cantaloups. Simultaneously, plant breeders are trying to develop a cantaloup plant from which all the melons will be taken in one harvest.

Crenshaw melons are very tender and require special care in all handling operations. They are cut from the vines and hand passed from man-to-man in crews to loaders in field trailers. Fruits of this variety are generally loaded only one or two layers deep. Casaba and Persian are

Cantaloup harvesting scene near Mendota, California. The pickers walk up an inclined board attached to the rear of the truck to unload the melons.

commonly picked in bags and then windrowed every sixth or eighth row, and are later put in field trucks or trailers.

Packing-Shed Operations

Most muskmelon packing sheds are located on railroad sidings in towns, often 10 or more miles from the fields. Loaded field trucks and trailers are parked near packing sheds to await unloading. When supplies of melons are light the delay from arrival to unloading is only a few minutes, but during peak volumes, it may be from two to three hours. Because such heavy volumes generally occur during warm weather, some grower-shippers park their trailers or trucks under specially constructed shelters to prevent sunburn and heating of the melons from prolonged exposure to the sun. A two-hour exposure to direct sunlight on a hot day (105° to 110°F) can increase sunburn, softening and susceptibility to bruising of cantaloups.

Receiving. Field trucks and trailers are unloaded through gates located along the entire length of one side of the vehicle bed. The trucks or trailers are driven up inclined driveways alongside of receiving units, either sloping, padded ramps (most common) or tanks of moving water. Tests have shown that wet-dumps of moving water containing a fungicide reduce bruising and scuffing injury that occurs during unloading operations. The melons roll by gravity down the ramps or into the water, from where they are conveyed into the packing sheds on a series of conveyor belts or rollers. Care must be used in the design of conveying systems in packing sheds to eliminate places where melons rub against sharp edges (e.g., worn edges of boards) or rough surfaces(e.g., areas where dirt accumulates on surfaces, or where the fruit tends to bunch).

Sorting. After receiving, the melons are sorted. Crews of six to ten sorters manning both sides of a sorting belt remove undersized, misshapen, immature, bruised, cracked, sunburned, decayed, and insect-damaged melons, along with those that have poorly developed nets ("slickers"). Sorting is a key operation for shippers who insist upon a high-quality pack. Substandard melons not culled by sorters are sometimes packed and shipped to markets. If this happens, the market quality and value of the product are seriously reduced before the melons leave the packing shed. Adequate light and sufficiently slow movement of melons, while rotating, past sorters are essential to effective sorting. In some packing sheds washing, waxing and fungicide applications are performed after cantaloups are sorted.

After cull fruits are removed, other sorters divert the melons onto different channels of the conveyor system, according to size, maturity, and quality. Each melon eventually moves into a bin with other fruits of comparable size, maturity, and quality.

Sizing. Cantaloups are sized visually (most common) and by mechanical sizers. In the latter method, a conveyor comprised of many rotating rollers, which spread increasingly farther apart as they move along, separates melons by one or two crosswise diameters. The rollers on some sizers are scalloped, similar to citrus sizers, which tends to increase their effectiveness. Crosswise conveyors beneath mechanical sizers carry the melons to packing stations. When properly used, mechanical sizers are generally more accurate than visual sizing.

Packing. All muskmelons are hand-packed into shipping containers. Packers stand beside bins containing melons of comparable size, maturity, and quality. Packs are denoted by the number of melons per container. Cantaloups are generally packed 23, 27, 36 or 45 per crate with three layers of melons per crate. Rarely, 18's or 54's are packed.

Only cantaloups of a given size, maturity, and quality are packed in a single crate. Cantaloups are commonly bulge-packed, sometimes excessively. The trade believes that bulge-packing is necessary to prevent loosening of the pack which results in "roller bruising" from transit vibration. Tests have shown, however, that bulge-packed cantaloups sustain much more physical damage than level-packed melons.

Maturities packed are—going from least to most mature—Hard Ripe, Eastern Choice, Western Choice and, in some sheds, Local Choice. Hard Ripe and Eastern Choice melons are shipped to more distant markets; Western and Local Choice to nearby markets.

Persian, Honey Dew, and Casaba fruits are packed in single-layer containers, either wood crates (most common) or cartons. In crates, the fruits are cushioned with excelsior to prevent rubbing and loosening of the pack. Except for Persian melons, it is better to overpack *slightly* than to slack-pack fruits of these varieties.

Each packed container bears the packer's number, the count size (number of melons in the container), and the maturity. The latter is denoted by the position of the count size stamp on the end of the container. These numbers help the tally clerk in each shed to record the numbers of containers packed by each packer, the maturity, and the count size. Brand labels generally indicate the quality of melons in a particular container.

After packing and tallying, the packed crates are lidded in semi-automatic lidding machines. Considerable bruising and cracking of cantaloups occurs in the lidding of excessively over-packed crates. Cartons are generally closed by passing them through "case sealers."

Shipping Containers. Cantaloups are shipped almost exclusively in wooden crates, mostly in Western Growers Association (WGA) cantaloup crates, but some in Standard cantaloup crates. These two container types have the same inside dimensions, but differ in their construction. Packed cantaloup crates average about 90 pounds gross weight.

A limited number of cartons are shipped, both ⅔ and ½ crate sizes. Difficulties with cartons have included inadequate refrigeration in some loads, insufficient wet-stacking strength for multiple pallet stacking in cold rooms, and high packing charges demanded by packers.

Other varieties of muskmelons are packed in Standard and Jumbo Honey Dew crates. Some are shipped in one-layer cartons. Unlidded vegetable crates are used for local and western shipments of some muskmelons (not cantaloups).

Numerous studies have been conducted by the USDA, shippers, and container manufacturers, to reduce handling and transit injury through improvements in container design, size, handling, and loading patterns. Such studies should be continued in order to reduce melon damage and thereby improve market quality.

Precooling. Three methods of precooling are used to remove field heat from cantaloups. Car cooling is done on rail sidings adjacent to packing sheds. Hydrocooling and forced-air cooling are performed in packing sheds.

Car cooling with top ice is the most widely used method. Refrigerated rail cars (and trucks) are loaded with packed crates of cantaloups; top ice is blown over the load, the amount depending upon the size of the load, fruit temperature when loaded, and the desired transit temperature. Thereafter, special precooling fans, having large air movement capacities, are turned on to circulate the cold air down through the melons to obtain cooling. Car cooling is generally a custom service provided by special precooling companies.

A few shippers use hydrocooling for precooling their cantaloups. The melons are generally hydrocooled before packing, although in one installation packed crates are hydrocooled. Both ice and mechanical refrigeration are used to cool the water in these systems. Some hydrocoolers are owned by the shippers; others are rented from ice companies.

Forced-air cooling is used for cooling cantaloups in one large-volume packing shed.

To prevent warming of melons after precooling, cantaloups should be immediately placed in refrigerated storage (cold rooms, rail cars, or trucks).

Thorough precooling, followed by refrigerated *storage* at about 35° to 40°F will allow shippers to market riper cantaloups (Eastern Choice and Western Choice) in distant markets. Casaba and Persian melons are precooled by some shippers when fruit quality, maturity, temperature, and marketing conditions suggest it is desirable. Usually Casaba and Persian fruits are cooled in refrigerated cars or turcks.

Honey Dew melons should generally

not be precooled. However, with the recent desirable trend toward shipping riper melons to distant markets, shippers have found that during hot weather at shipping point some precooling after adequate gassing is beneficial. This practice permits marketing riper melons with minimum losses from fruit softening.

Ethylene Gas Treatment of Honey Dew Melons. The purpose of ethylene gassing of Honey Dew melons is to make the ripening process uniform and more rapid. Honey Dew melons harvested at Eastern Choice maturity (35 to 39 days after flowering) will not ripen fully unless treated with ethylene gas. More mature, Western Choice Honey Dew fruits commonly produce enough ethylene to ripen fully, but not rapidly enough to be ripe upon arrival at destination markets.

Honey Dew is commercially gassed with ethylene at concentrations of 1,000 to 10,000 ppm for 12 to 24 hours. Numerous studies have shown that a concentration of 1,000 ppm is sufficient if applied for at least 18 hours with pulp temperatures above 70°F. No advantage is obtained from using higher concentrations but longer exposures may be required. Rail shipments are treated in dry (nonriced) refrigerator cars on sidings next to packing sheds. Truck shipments are generally treated in special ethylene gassing chambers at sheds before loading. Occasionally, loaded trailers are held overnight at packing sheds for treatment with ethylene gas.

The following points may help Honey Dew shippers and handlers understand the effects of ethylene gassing:

- Ethylene will not ripen immature melons. The 10 per cent soluble solids requirement of the Agricultural Code of California for Honey Dew of Eastern Choice maturity is a good indication of minimum ripening maturity. If the soluble solids content is less than 10 per cent, the melons will not respond satisfactorily to treatment with ethylene gas.
- Treatment with ethylene gas does not increase the soluble solids content of the fruit.
- Fruit temperatures must be at least 70°F for ethylene gas to be effective. Honey Dew fruits harvested in the fall commonly need warming before treatment is effective.
- In fruits of Eastern Choice maturity ethylene gas helps stimulate production of the gas by the fruit, which then assists further in the ripening process.
- Even with more mature melons (e.g., Western Choice) ethylene gas speeds up the ripening process and makes the ripening of a whole shipment more uniform.
- The principal responses from treatment with ethylene gas are better development of color, wax, aroma, and softening.

Inspection

In order for his product to be certified as meeting U.S. Standards for Grades of Cantaloups, a shipper must have his melons inspected by a federal-state shipping point inspector. Inspection provides an indication of quality at shipping point for both shipper and receiver. A service charge for the inspection is paid by the shipper. A fee is charged in some counties for inspections to determine compliance with the Agricultural Code of California.

The California Agricultural Code requires a minimum soluble solids (determined by refractionates) of 8 per cent for cantaloup and 10 per cent for Honey Dew shipped to fresh markets.

Shippers, buyers, and other interested persons should familiarize themselves with the U.S. Standards for Grades of Cantaloups and for Honey Dew Melons, and with pertinent sections of the Extracts from the Agricultural Code of California. These publications describe minimum U.S. and California Code requirements for muskmelons. Copies of the U.S. Standards can be obtained from the Fresh Fruit and Vegetable Division, Agricultural Marketing Service, Washington, D.C. County Agricultural Commissioners have information on California Agricultural Code requirements for muskmelons.

Transportation and Refrigeration

Recent extensive improvements in transportation and refrigeration services and equipment have benefited the western

muskmelon industry. Such developments include:

- Incentive rates for heavier loads and per-car rates in railroad shipments
- Availability of more mechanically refrigerated cars
- Faster railroad schedules that have reduced transit times to market
- Use of modified icing schedules, at considerable savings to shippers
- Use of piggy-back, TOFC (trailer on flat car) service, which provides pickup and delivery service of loads at lower rates
- Development and use of larger and improved, over-the-road trucks having greater air circulation and refrigeration capacities, better insulation, and improved floor racks
- Development of container units (small refrigerated vans that can be removed from truck chassis) for overseas shipments
- Use of hydrocooling and forced-air cooling at packing sheds for precooling truck shipments before loading.

About two-thirds of the cantaloup crop is shipped by rail and the balance by trucks. Transit periods by truck are shorter than by rail. Railroad cars, however, provide a ready precooling facility, have greater refrigeration capacity, and are able to maintain desirable fruit temperatures (35° to 40°F for cantaloup, 45° to 50°F for Honey Dew) more easily.

In tests conducted by the USDA, comparable transit temperatures were obtained in shipments of heavy (416 to 432 crates) and light (324 crates) loads of cantaloups under the same icing schedules. Transit temperatures and market quality were not significantly different in melons shipped under standard refrigeration full-bunker icing, half-stage standard, and full-bunker modified icing (two re-icings in transit). Use of heavier loads and modified or half-stage icing should result in substantial savings to shippers. These savings could be realized without sacrificing quality. However, modified icing services may not be successful in protecting riper Honey Dew melons during the warmest part of the harvest season. since these loads are not usually precooled.

For Further Reading

For those desiring further information about specific aspects of muskmelon production, the references cited below will be helpful.

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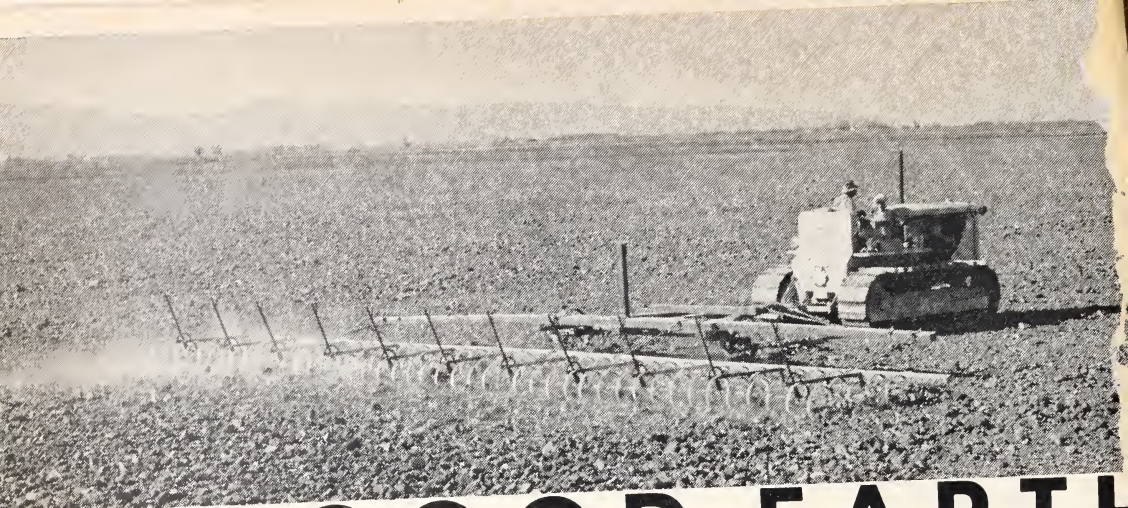

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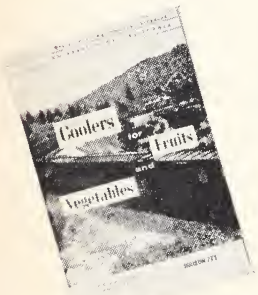

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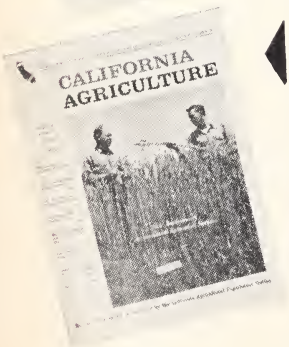

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